Barotrauma

Presented by the NOAA Diving Center
Seattle, Washington

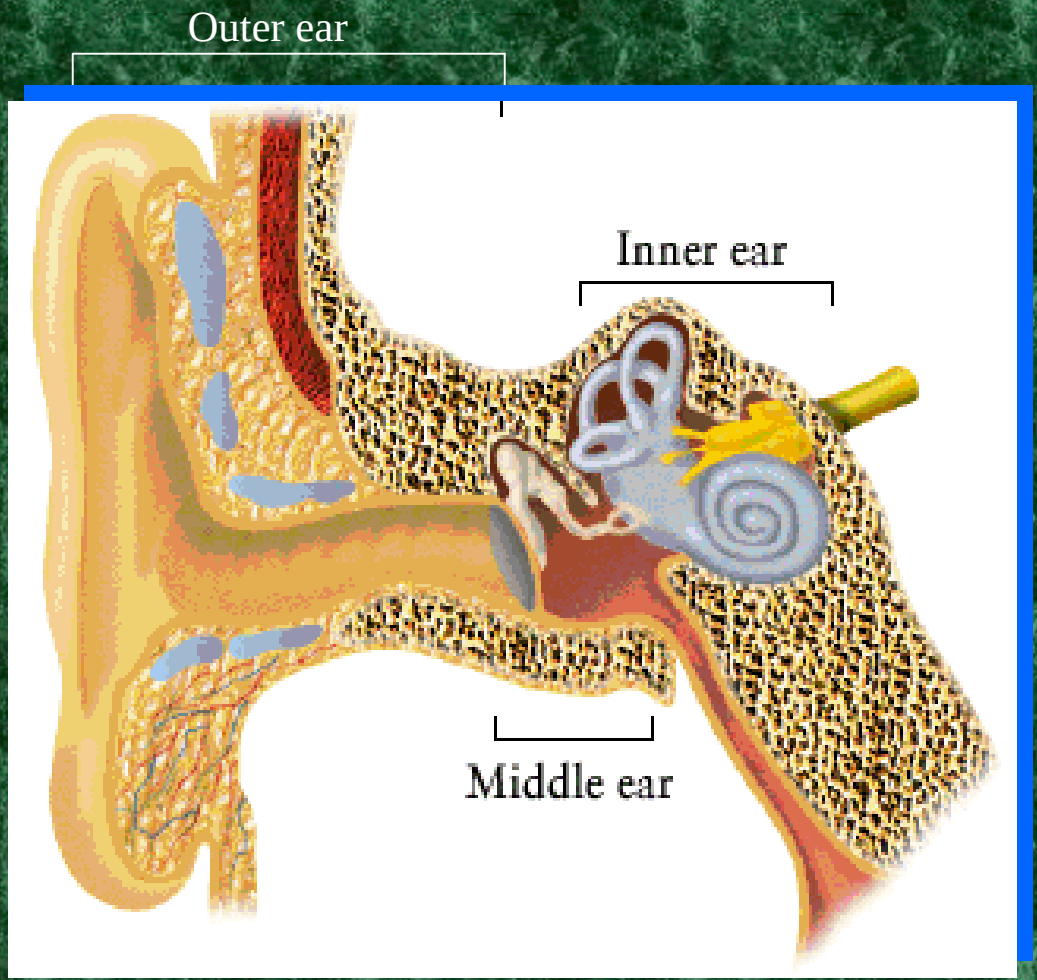
Barotrauma During Descent

- Ear barotrauma
- Sinus barotrauma
- Dental barotrauma
- Equipment barotrauma
- Pulmonary barotrauma

Definition: “Baro” means pressure and “trauma” means injury, thus pressure-related injuries!

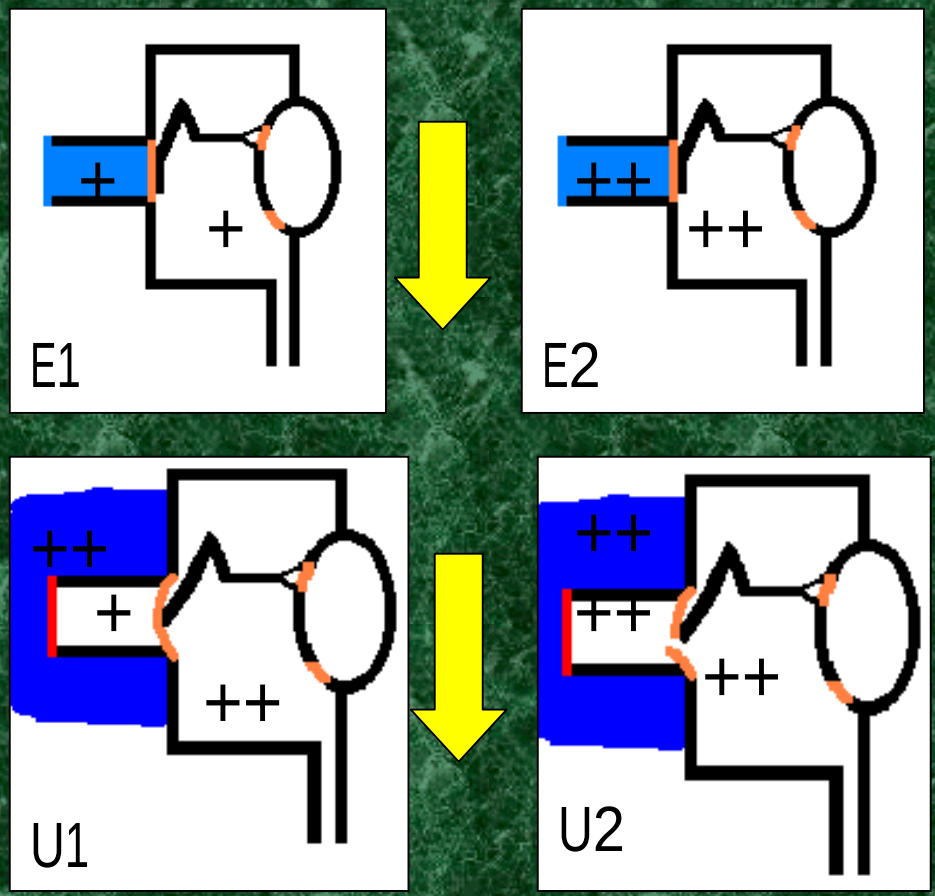
Ear Barotrauma-1

- Cause: Unequal pressures on air spaces
- Anatomy:
  - Outer ear
  - Middle ear
  - Inner ear
- Types:
  - Outer ear squeeze
  - Middle ear squeeze
  - Round window rupture



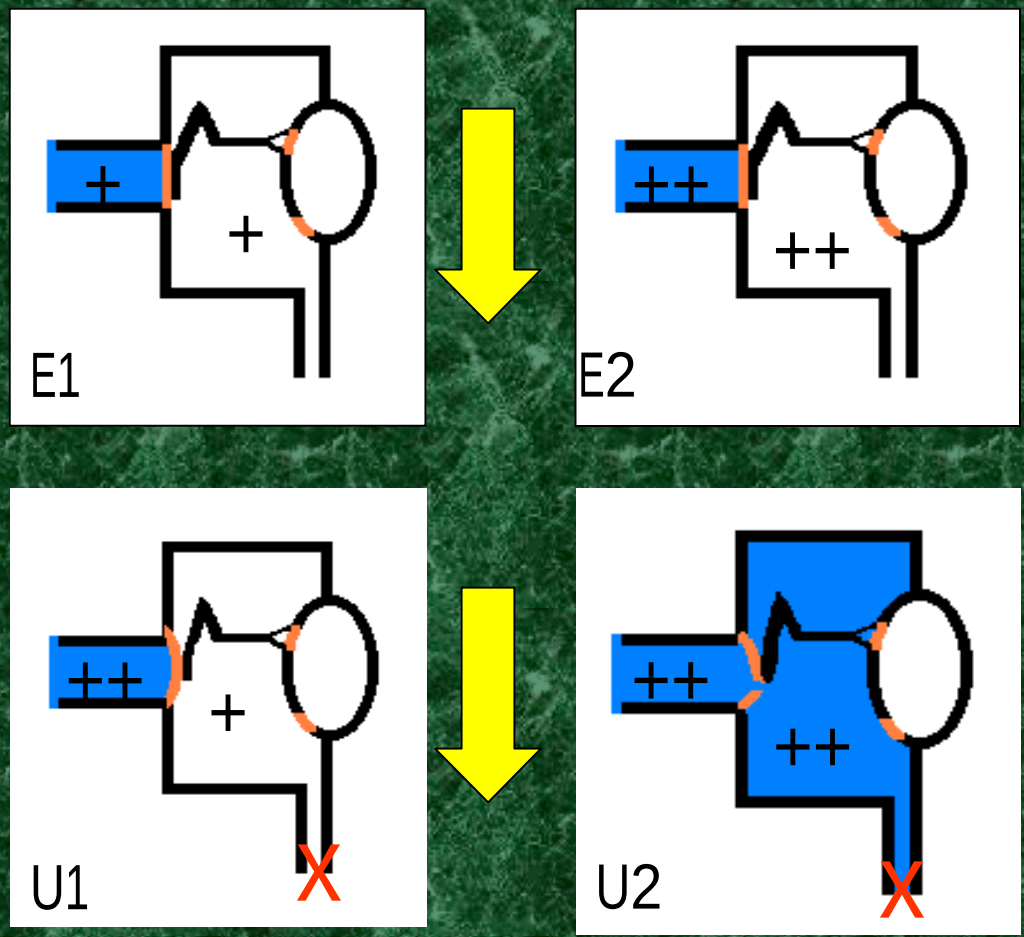
Outer Ear Squeeze

- Cause: Tight-fitting hood, plug in ear canal
- Effect: Causes ear drum to bulge outward; can rupture



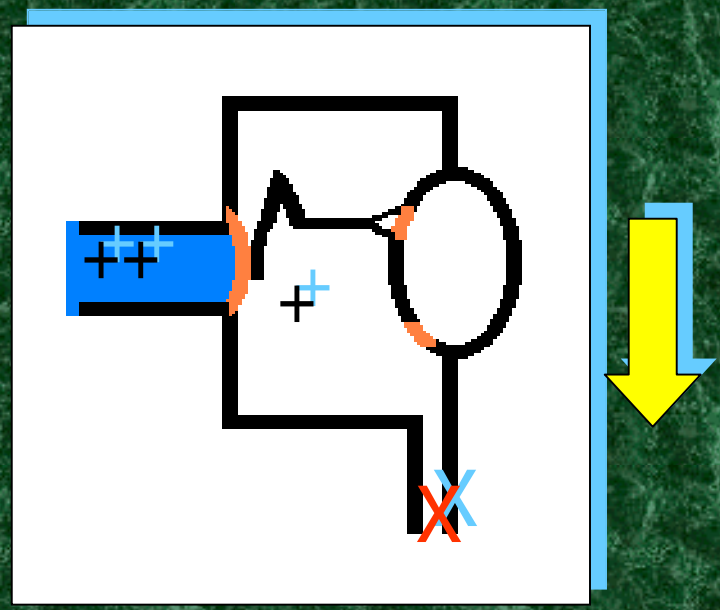
Middle Ear Squeeze

- Cause: Blocked eustachian tube
- Effect: Causes ear drum to bulge inward; can rupture



The Trapdoor Effect

- The end of Eustachian tube is surrounded by soft tissue in the throat
- When equalization is delayed, ambient pressure in the throat holds the eustachian tube shut and prevents equalization
- Equalize early and often to prevent the trapdoor effect

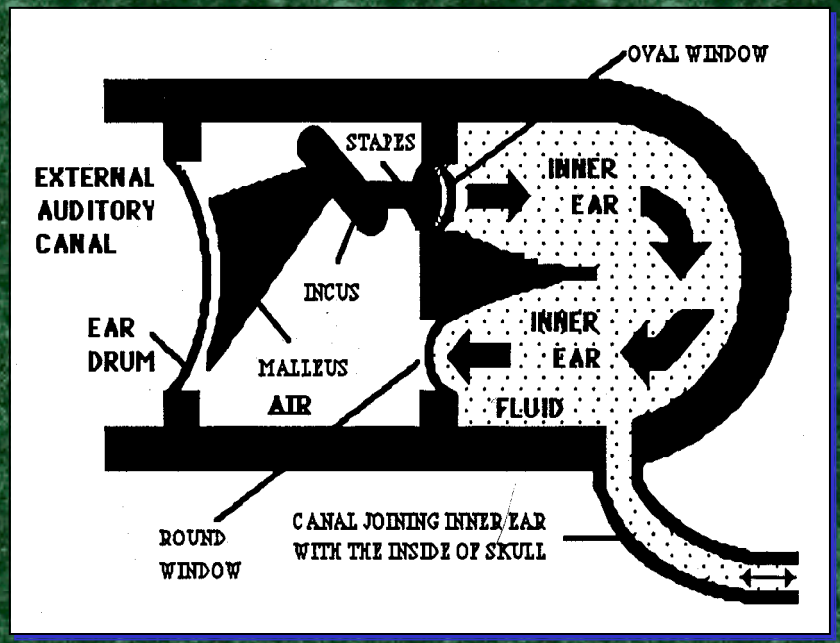


Ear Barotrauma-2

- Signs & symptoms:
  - Squeaking sound during equalization
  - Pain and pressure then sudden relief
  - Vertigo
  - Fullness or “stuffiness” after surfacing
  - Muffled hearing
  - Ringing in the ear
  - Echo sensation
- Treatment
  - Have victim sit down, remain still, & keep quiet
  - If vertigo, have victim lie down with head elevated, close eyes, keep quiet, and remain still
  - No coughing, straining, bending, nose blowing, equalization attempts, flying, high elevations
  - No further diving until medical evaluation
  - No taking any medication, putting anything in ears
  - Immediate medical care by an ENT physician

Round Window Rupture

- Cause: Excessive force used to equalize middle ear on descent
- Effect: Round window bulges outward and ruptures
- Signs & symptoms: Pain, vertigo, nausea
- Treatment: Immediate medical attention by a ENT



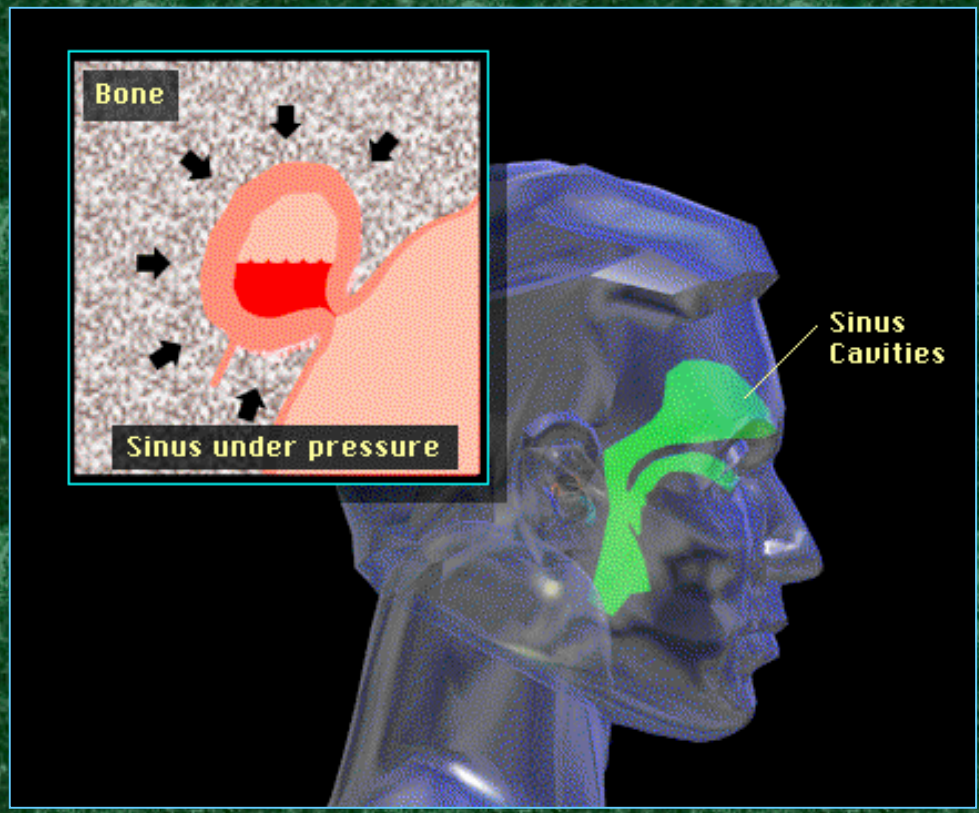
Equalize gently, early, and often!

Sinus Barotrauma-1

- Four sets of sinuses:
  - Frontal: Above the eyes
  - Ethmoidal: Behind the cheek bones
  - Sphenoid: Deeper behind the eyes
  - Maxillary: Behind the nose
- Healthy sinuses equalize automatically
- Congested sinuses do not equalize
- Unequalized sinuses are painful
- Pressure can build in sinuses during ascent

Sinus Barotrauma-2

- Cause: Blocked passages to sinuses
- Effect: Unequal pressure inside versus outside



If you need medication to open air passages, you probably shouldn't be diving!

Sinus Barotrauma-3

- Signs & symptoms:
  - Increasing pain and pressure around sinus areas
  - May have sudden relief of pain
  - Bloody discharge in mouth or mask
- Treatment
  - Have victim sit down, remain still, & keep quiet
  - If vertigo, have victim lie down with head elevated, close eyes, keep quiet, and remain still
  - No coughing, straining, bending, nose blowing, equalization attempts, flying, high elevations
  - No further diving until cause is resolved
  - No taking any medication

Dental Barotrauma

- Causes: Unequal pressure inside an air pocket in or around a tooth due to:
  - Tooth decay
  - Incomplete filling
- Effect: Vacuum (on descent) or over-pressurization (on ascent) puts pressure on nerve ends

- Signs & symptoms:
  - Direct, boring pain in tooth
  - Bleeding from around tooth
- Treatment:
  - Discontinue diving
  - Analgesic for pain
  - Seek dental assistance

Equipment Barotrauma

- Types:
  - Mask
  - Dry suit
- Cause:
  - Unequalized air space
- Effects:
  - Mask: Pulling sensation on face & eyes
  - Suit: Pinching
- Signs & symptoms:
  - Mask: blood-shot eyes, puffy face, discomfort
  - Suit: Welts
- Treatment:
  - Equalize equipment air spaces early & often
  - Seek medical attention if problem is severe

Barotrauma During Ascent

- Reverse squeezes
- Lung barotrauma
  - Subcutaneous emphysema
  - Mediastinal emphysema
  - Spontaneous pneumothorax
  - Arterial gas embolism

Reverse Squeezes-1

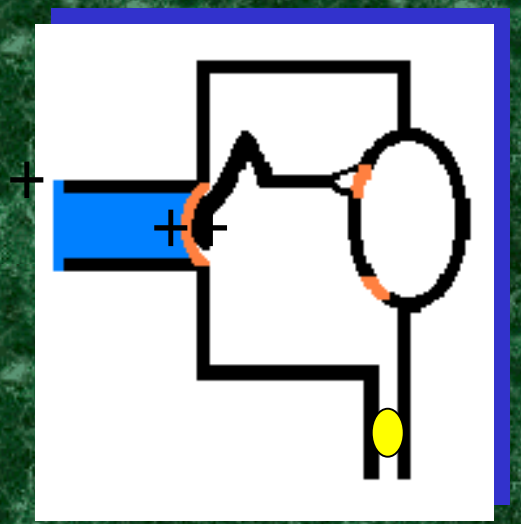
- Types:
  - Ear
  - Sinus
  - Tooth
- Causes:
  - Mucus plug in air passage
  - “Rebound” effect from medication
- Effect: Pain

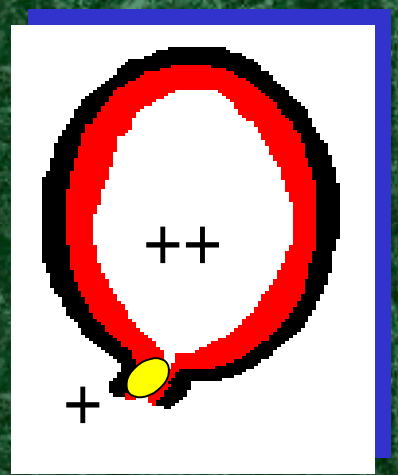
- Actions:
  - During Dive: Slow or stop ascent to allow pressure to vent
  - Discontinue diving
  - Seek medical help if problem is severe or persistent

Rebound Effect: Decongestant medications can wear off quickly under pressure and can cause air passages to close tightly

Reverse Squeezes-2

- Prevention: Have clear, healthy ears and sinuses when diving
- Treatment:
  - Seek medical advice if condition persists
  - If ear drum bursts, put nothing in ear and seek medical assistance





Pulmonary Barotrauma

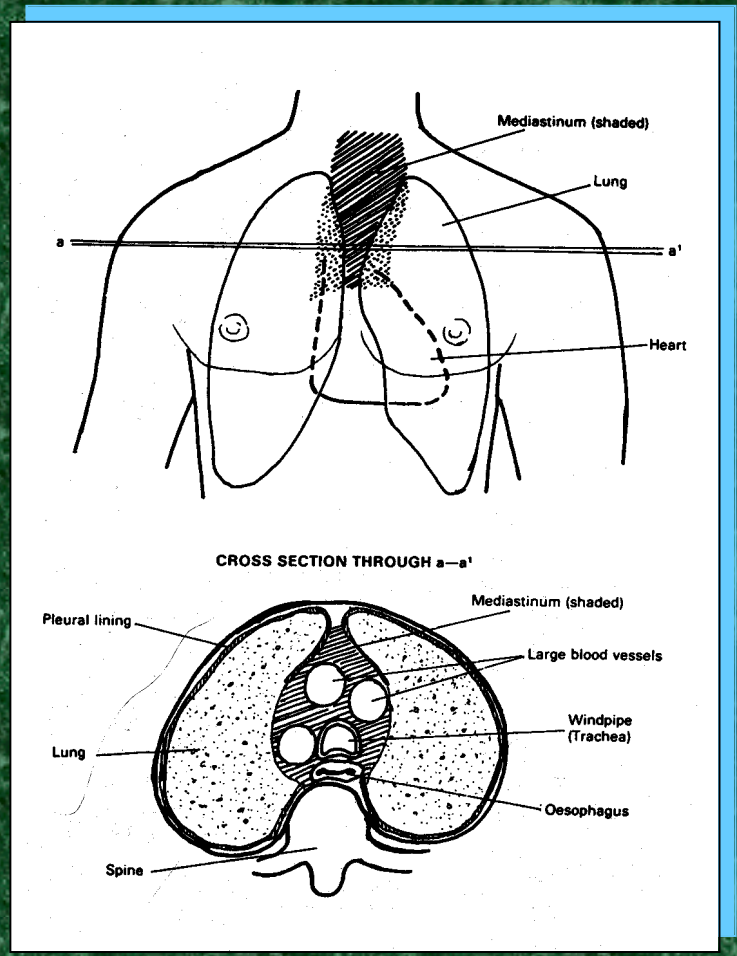
- Causes:
  - Holding breath while ascending with compressed air in lungs
  - Air trapped in part of lung from mucus plug or lung defect

Lung injuries are urgent medical emergencies

- Types:
  - Mediastinal emphysema: Air in middle of chest
  - Subcutaneous emphysema: Air under skin at base of neck
  - Pneumothorax: Air in chest cavity - simple or tension
  - Arterial gas embolism: Air bubble in artery blocking circulation

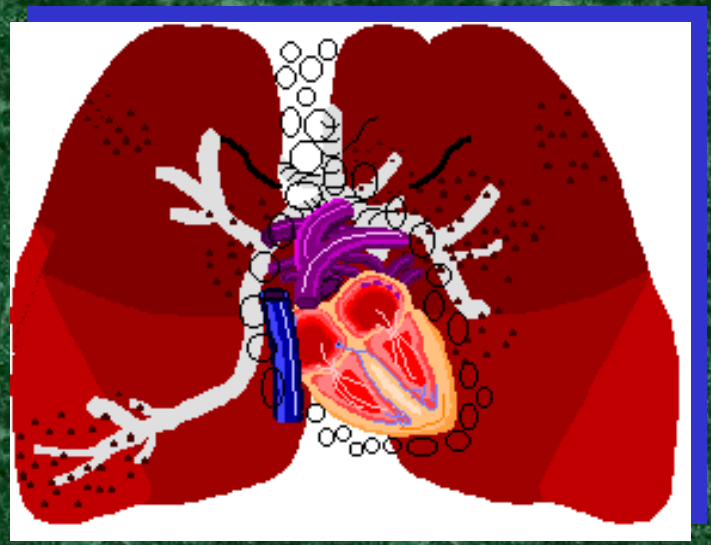
Mediastinal Emphysema-1

- Cause: Over-pressurization of lungs resulting in a tearing of the alveoli allowing gas to escape into the tissues of the lung. Gas tracks along the lung tissues to the area under the breastbone
- Effect: Air expanding in middle of chest may affect circulation and breathing



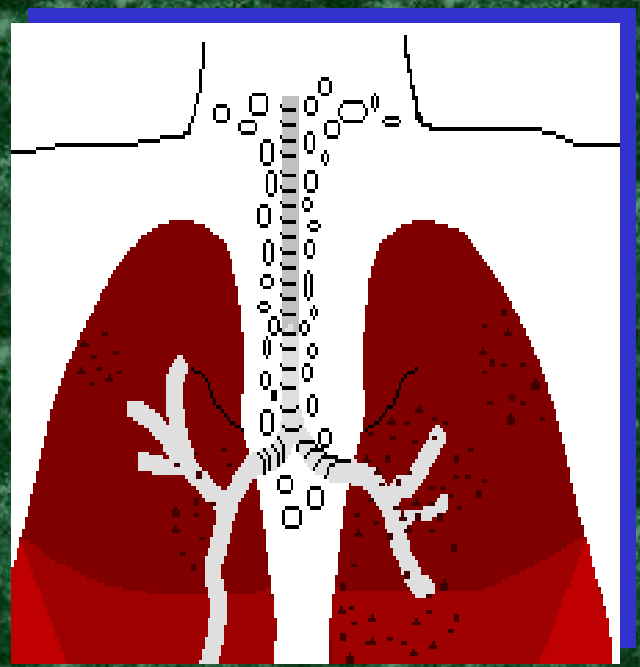
Mediastinal Emphysema-2

- Signs & symptoms:
  - Sudden, severe pain in chest
  - Shortness of breath
  - Possible fainting
  - Difficulty breathing
- Treatment:
  - ABC's
  - Administer oxygen and monitor for shock
  - Examine diver for other signs of pulmonary barotrauma
  - Mediastinal emphysema causing respiratory or circulatory impairment may require recompression



Subcutaneous Emphysema-1

- Cause: Over-pressurization of lungs resulting in a tearing of the alveoli allowing gas to escape into the tissues of the lung. Gas tracks along the lung tissues to the area under the breastbone then to the neck region
- Effect: Air expanding under skin at base of neck may affect swallowing, talking, and breathing

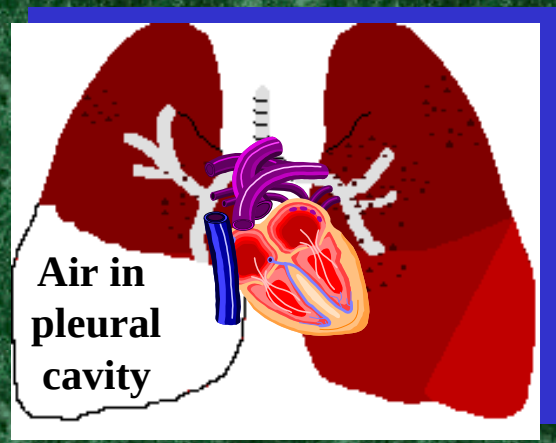


Subcutaneous Emphysema-2

- Signs & symptoms:
  - Skin crackles when squeezed
  - Fullness in neck
  - Voice change
  - Swallowing, talking, breathing difficulties
- Treatment:
  - ABC's
  - Administer oxygen and monitor for shock
  - Examine diver for other signs of pulmonary barotrauma
  - Recompression not normally required

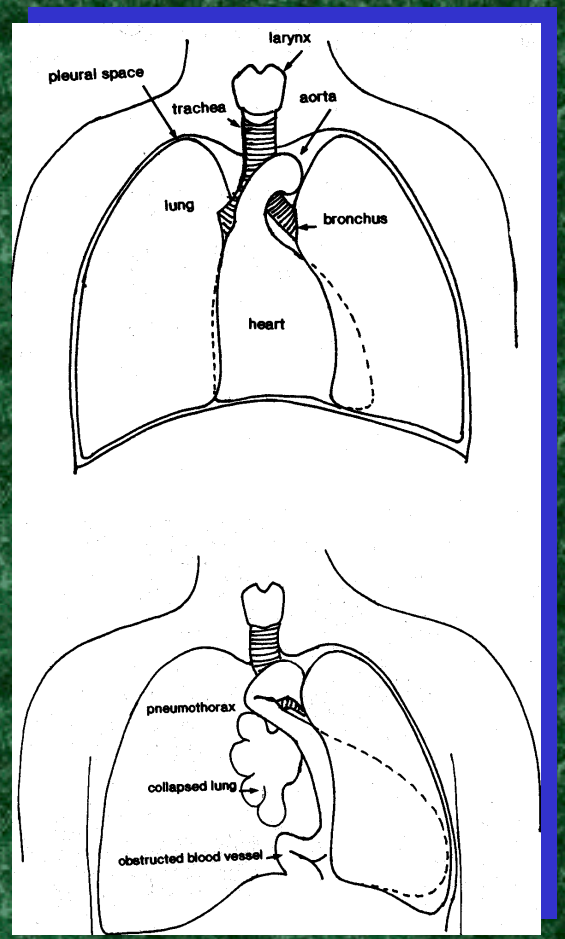
Pneumothorax-1

- Simple Pneumothorax:
  - Cause: Lung over-pressurization resulting in a one-time leakage of air into the pleura space between the lungs and chest wall
  - Effect: Lung partially collapses
- Tension Pneumothorax:
  - Cause: Air continues to enter but not exit the chest cavity with each successive breath thus progressively enlarging the air pocket
  - Effect: Lung totally collapses - expanding air exerts pressure on heart, trachea, esophagus, etc



Pneumothorax-2

- Signs and symptoms:
  - Difficulty or rapid breathing
  - Leaning toward affected side
  - Hypotension
  - Cyanosis & shock
  - Chest pain (deep breath hurts)
  - Shortness of breath
  - Decreased or absent lung sounds on affected side
  - Death



Pneumothorax-3

- Treatment:
  - Simple Pneumothorax:
    - Normally improves with time as air is reabsorbed
    - Monitor for signs of tension pneumothorax
    - Monitor ABC's and administer oxygen
    - Transport to nearest medical facility
  - Tension Pneumothorax:
    - Position patient on injured side
    - ABC's
    - Treat for shock & administer 100% oxygen
    - Transport immediately to nearest medical facility (air must be vented from chest cavity)

Arterial Gas Embolism-1

- Cause: Over-pressurization of lungs resulting in the tearing of alveoli allowing gas to enter the blood circulation. Bubbles are conducted to the left side of the heart then to other parts of the body through the arterial circulatory system
- Effect: Air bubbles block arteries--usually in brain

Arterial Gas Embolism-2

- Signs & symptoms:
  - Disturbances of the brain function
    - Sensation (i.e. numbness or tingling)
    - Movement (i.e. paralysis or weakness)
    - Vision
    - Speech
    - Balance or coordination
  - Chest pain
  - Shortness of breath
  - Bright red frothy sputum
- First Aid:
  - Provide life support
  - Keep victim horizontal continuously
  - Administer 100% oxygen
  - Transport victim to medical facility for immediate recompression

Signs & symptoms appear rapidly (5-10 mins.)

Key Points

- Keep pressure in air spaces equal to the surrounding pressure at all times
- Breathe continuously when using scuba
- If you need medication to open air passages, don't dive
- Signs and symptoms of arterial gas embolism occur within 5-10 minutes after surfacing
- AGE is the most serious of all diving injuries and requires recompression therapy